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AUTHOR Yeany, Russell H.; Adams, Wenda J.
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ABSTRACT

This paper summarizes and compares three studies which used different approaches to diagnostic/prescriptive instruction: (1) voluntary diagnosis and remediation; (2) required diagnosis with no formal remediation; and (3) required diagnosis with prescribed remediation. It includes an examination of the influence of selected student entry characteristics on the effectiveness of the diagnostic/prescriptive instruction, including locus of control. Procedures and results of the three studies and conclusions regarding the influences of various forms of diagnostic/prescriptive instruction and selected student entry characteristics on achievement of university biology students are presented. (CS)

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IMPROVING THE ACHIEVEMENT OF COLLEGE BIOLOGY STUDENTS THROUGH THE USE OF DIAGNOSTIC PRESCRIPTIVE INSTRUCTION

Russell H. Yeany
Department of Science Education
University of Georgia
Athens, Georgia

Wenda J. Adams
North Carolina State University
Raleigh, North Carolina

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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IMPROVING THE ACHIEVEMENT OF COLLEGE BIOLOGY STUDENTS THROUGH THE USE OF DIAGNOSTIC PRESCRIPTIVE INSTRUCTION

Traditionally, university students have been expected to guide and direct their own study efforts in order to acquire knowledge and skills related to a particular course or program. This view assumes that students can focus on the expected outcomes, diagnose their level of competence and engage in effective study and remediation when necessary. Recently, some university instruction has been centered around performance objectives which help clarify the expected outcomes. The next logical step in developing an instructional system, after providing students with performance objectives, is to develop a means for diagnosing student achievement and providing for feedback and remediation (Yeany, Dost and Matthews, 1980). The combination of the use of performance objectives, diagnostic testing, and prescribed remediation provides the basis for a diagnostic/prescriptive instructional system which can be summarized as follows:

Step 1 -- Specify performance objectives;

Step 2 -- Develop diagnostic measures for objectives;

Step 3 -- Teach using any preferred procedures;

Step 4 -- Test achievement of objectives using diagnostic measures;

Step 5 -- Remediate and rediagnose, if desired; and,

Step 6 -- Administer summative test (Okey, 1974).

Two problems are inherent to the reteach-retest practices about which diagnostic/prescriptive systems revolve. The first is that of the time required to recycle the students. Significant amounts of time are spent in developing materials, and in prescribing each student's specific learning

difficulties. The second problem is that of management. Matching the students with the appropriate remedial or enrichment activities, checking on progress, reassessing further problems or determining achievement, reassigning remedial activities, and so on, are formidable tasks. Situations which can accommodate these reteach-retest practices do exist, and instructors with the requisite management skills required to utilize systems of reteach-retest with minimal problems are available. However, there are also situations in which, for whatever reasons, reteach-retest procedures cannot be employed (Yeary, Waugh and Blalock, 1979).

The primary purpose of this papers is to compare three approaches to diagnostic/prescriptive instruction: 1) voluntary diagnosis and remediation; 2) required diagnosis with no formal remediation, and 3) required diagnosis with prescribed remediation. Since no single study which compared these three approaches was available, three separate studies which used college biology students were compared (i.e., Yeany, Waugh and Blalock, 1979; Yeany, Dost and Matthews, 1980; and Adams, 1980).

Also of interest in these studies was the influence of selected student entry characteristics on the effectiveness of the d-p systems. Two of the studies examined the effects of locus of control while one looked at differences related to ability levels. The extent to which students with various ability levels will benefit from the identification and remediation of learning needs is not certain. Similarly, some students may possess an external locus of control whereby achievement is perceived as the result of luck, chance, fate, or under the control of powerful others. In contrast, other students may perceive achievement as entirely contingent upon their own behavior, effort, or actions (i.e., internal locus of control). It

follows that those students with an internal locus of control orientation would exhibit a greater willingness to participate in a diagnostic-prescriptive learning environment and thereby achieve at a higher level than the non-participants.

PROCEDURES AND RESULTS

The procedures and results for each of the three studies are given separately in this section. The "diagnosis only" study is presented first, the "diagnosis with prescribed remediation" second, and the "voluntary diagnosis" study last. The order represents the order in which the studies were conducted.

DIAGNOSIS ONLY STUDY

Data Sources

The subjects in the study were seventy-five preservice teachers enrolled in four sections of an introductory biology course at the University of Georgia. Pretreatment data were collected on the average achievement level of each student on the units of study covered prior to experiment conditions. These data were used as covariates to adjust for selection bias and to increase the statistical power of the analyses. Pretreatment data were also collected on student ability level as assessed by SAT scores. Posttreatment science achievement data were collected at the end of two units--one on Animal Behavior and one on Ecological Principles. Two sections were involved one quarter and two more in a following quarter. This effectively allowed for a replication of the study. The treatment was administered over two complete units of instruction each quarter. A summative measure was taken at the end of each unit.

Treatment Levels

The treatment in this study consisted of two levels:

LEVEL I-OBJECTIVES ONLY -- Subjects in this level recieved a set of performance objectives prior to instruction for each unit of study during the experimental period (this was an established procedure in the course). The subjects were not administered any diagnostic measures nor did they receive any formal feedback prior to summative testing for the unit of study.

LEVEL II-OBJECTIVES AND DIAGNOSIS -- Subjects in this level received the same performance objectives as Level I. In addition, at the end of each class period, they completed a diagnostic quiz over all the objectives covered during the immediate session. A self-correcting key was attached to the back side of each quiz which allowed the students to immediately assess their achievement on the session's objectives. All experimental subjects understood that the diagnostic quizzes were not used for grading purposes. No formal reteaching of concepts occurred.

Results

Mean achievement scores on the Animal Behavior unit for both quarters are given in Table 1. Analysis of these data indicated non-significant treatment effects ($p=.15$, and $p=.99$). A significant Treatment X Ability interaction was found (see Table 2). In order to determine the nature of this interaction, the cell means were graphed as Figure 1 which indicates that the influence of the treatment was not consistent across ability levels. The diagnostic feedback seemed to benefit the higher ability students more than the lower ability. The analysis of ability group effect indicated that neither ability group significantly outperformed the other in either quarter of the study.

Table 3 shows the mean achievement scores on the Ecological Principles unit. The F ratios from the ANOVA procedures indicate significant treatment effects in favor of the experimental group in both studies ($p<.01$) (see Table 4). No Treatment X Ability interactions occur in these data. Also, neither ability group outperformed the other to a significant extent.

DIAGNOSIS WITH REMEDIATION ONLY STUDY

Data Sources

The subjects in this study were enrolled in two sections of an undergraduate introductory biology course at the University of Georgia.

Pretreatment data were collected on the achievement of all subjects on three course achievement measures. Both sections received the same objective referenced examinations on all units. The mean of these three scores was used as a covariate in the statistical analysis to increase the power of the hypothesis testing and to adjust for selection bias that could be identified through prior achievement in the course.

Data on locus of control were collected with the Rotter (1966) LOC measure during the week prior to treatment. Subjects who scored at or above the mean ($\bar{x}$=10) were identified as "internal"; others were identified as "external".

Posttreatment data were collected on the student achievement with an objective reference measure which was identified as a "unit test" on evolution. The score on a unit test accounted for one-tenth of the grade for the course. This was the last of five such tests. The content validity of the measure was insured by assigning five biology instructors to write items for specific objectives at three taxonomic levels (i.e., recall, comprehension, and higher), and each item was reviewed by the entire group to assess how well it measured the objective at the stated level. Items which were identified as inappropriate were rewritten.

Treatment Levels

COMPARISON GROUP-OBJECTIVES ONLY -- The usual procedure in the biology course was to provide each student with performance objectives which guided instruction and student evaluation. The organic evolution unit consisted of sixteen objectives. The subjects in this treatment level received the usual unit objectives and experienced instruction which included lecture-discussions, a slide tape presentation, two laboratory sessions and one homework assignment. The instructional procedures were not unique to the unit; the sessions were considered normal for the course.

EXPERIMENTAL GROUP-DIAGNOSIS AND PRESCRIPTION -- Subjects in this treatment level received the same performance objectives and instruction as the above group and followed an identical time schedule (i.e., 4-5 objectives per session). In addition, they completed regular diagnostic measures which were keyed to the objectives and received remedial assignment when necessary.

For each of the objectives, two remedial assignments had been preselected on the basis of appropriateness for a particular objective. Mostly these consisted of a short (i.e., one or two pages) reading assignment from sources other than the course text. But, activities such as viewing a film loop, listening to a tape or discussing a concept with an instructor were also included. A file folder was set up for each subject from which he obtained the diagnostic measure at the beginning of the session and the necessary remedial assignments at the end of the session. All reading assignments were photocopied and placed in the folder. Diagnostic quizzing required about 5 minutes with each student completing a short quiz which covered all objectives from the previous class session. If a student received a remedial assignment, he was rediagnosed on those objectives concurrent with the diagnosis for the new subset of objectives. While the quizzes were marked by an assistant, daily instruction continued on schedule toward the next subset of objectives. Students were not required to master the objectives before the class proceeded. Also, no formal class time was taken to reteach an objective. Remediation was prescribed through the diagnostic remedial strategies but the responsibility of completion was left to the student.

Results

The statistical analysis indicated that, on the total criterion measure, the d-p group achieved significantly higher than the objectives only group ($p=.04$) (Table 2). This difference represented a 10 percent increase in achievement in favor of diagnostic-prescriptive instruction.

When the cognitive level subtest data were analyzed, the differences in achievement appeared to exist in the recall level items ($p=.05$) (see Table 2). No other significant influences of treatment were found in the achievement results ($p>.05$), and no effects of locus of control an achievement or LOC X treatment interactions were found ($p=.99$).

VOLUNTARY DIAGNOSIS STUDY

Data Sources

The subjects for this study were the students enrolled during the spring of 1980 in the introductory biology course at North Carolina State University.

Measures of the following variables were collected at the beginning of the course: locus of control; achievement motivation; and aptitude. Measures of achievement were collected at each summative examination.

Achievement was defined by the scores on teacher-constructed, multiple-choice examinations. Each examination consisted of 50 items, except for the final examination which contained 75 items. Scores for the three regular examinations were based on a 100-point scale and the final examination was based on a 150-point scale.

Treatment

> The students were allowed and encouraged to participate in diagnostic-prescriptive testing on a voluntary basis outside of class. Each diagnostic test consisted of 20 multiple-choice questions designed to check the student's mastery of the concepts of the topic. The first 15 questions tested the lower order of learning, primarily recall and knowledge, while the last five questions checked higher levels of learning, e.g., synthesis and analysis.

An analysis sheet accompanied each diagnostic test which gave the student the correct answers, an explanation of each question, and identified the course material tested by the question. The answers were checked by the instructor and the student was allowed to discuss the answers. If the student missed a question, the analysis sheet indicated what material should be studied to learn the correct answer. The tests were offered on an optional basis in the Learning Center which was established to provide the student with an opportunity to get repetitive, remedial, and advanced instruction on an individual or group basis.

Results

Since this was not an experimental study, data were analyzed through regression analysis. In this case, the number of diagnostic tests voluntarily taken by each student was used to predict achievement after variables such as academic ability, locus of control, and achievement motivation had been accounted for.

The analyses indicated that for all achievement measures participation in the voluntary testing improved achievement. These results were supported by the fact that a significant amount of achievement variance on each test was predicted by the number of diagnostic-prescriptive tests taken ($p=.0001$ to $.0182$) (see Table 3).

The percent of variance which could be predicted by the variables of locus of control, academic aptitude, achievement motivation, and the number of diagnostic-prescriptive tests taken was determined by regression model analysis. Table 4 indicates that the best single predictor of achievement was the number of diagnostic-prescriptive tests taken. External chance locus of control, internal locus of control, SAT verbal, and SAT quantitative were also consistent as strong predictors. The best model predicted 22% of the achievement on examinations, while the least predictive model accounted for 6%.

SUMMARY AND CONCLUSIONS

The influences of various forms of diagnostic-prescriptive instruction and selected student entry characteristics on achievement of university biology students were the focus of this study. The subjects in the studies were 350 university students enrolled in introductory biology courses at the University of Georgia and North Carolina State University. Treatments included voluntary achievement diagnosis and remediation, required diagnosis with no formal remediation, and diagnostic/remedial cycling to mastery. Achievement motivation, locus of control, and ability were among the student variables examined for their effects on learning and potential interactions with instruction. It is not possible to directly compare the effects of the different forms of diagnostic testing examined in these three studies because of variations in data analyses (i.e., testing of mean scores vs. testing of regression models). But the results indicate that in all cases the form of diagnostic-prescriptive instruction significantly and positively influenced achievement. A "warm-up" period for each method was also identified. That is, initial usage had a small effect; but, continued use caused an increasing magnitude of effect.

In regard to student variables, the method that provided only diagnostic feedback favored high ability students. But, the voluntary procedures were more appealing to the lower ability students. Student locus of control also seemed to have some effect where the middle locus of control students exhibited the greatest tendency to volunteer for diagnostic testing. Overall the practice of diagnosing and providing remediation to students proved to be an effective and feasible way to improve biology achievement in university students.

All modification in existing instructional procedures include costs in terms of time and effort. The case of d-p instruction is no different but the probability of a benefit in increased achievement is high.

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TABLE 1

CELL, MARGINAL, AND GRAND MEAN SCORES FOR ACHIEVEMENT IN THE ANIMAL BEHAVIOR AND ECOLOGICAL PRINCIPLES UNIT

			ABILITY		
			HIGH	LOW	
ANIMAL BEHAVIOR	FIRST QUARTER N=30	OBJECTIVES + DIAGNOSIS	46.6	43.6	45.4
		OBJECTIVES ONLY	40.9	45.3	43.1
			44.8	44.2	44.5
	SECOND QUARTER N=45	OBJECTIVES + DIAGNOSIS	44.0	44.0	44.0
		OBJECTIVES ONLY	44.4	43.4	43.7
			44.0	43.7	43.9
ECOLOGICAL PRINCIPLES	FIRST QUARTER N=30	OBJECTIVES + DIAGNOSIS	40.5	37.4	39.2
		OBJECTIVES ONLY	33.6	35.0	34.3
			38.4	36.6	37.5
	SECOND QUARTER N=45	OBJECTIVES + DIAGNOSIS	39.8	39.0	39.6
		OBJECTIVES ONLY	36.8	34.3	35.0
			39.2	36.2	37.8

TABLE 2

UNADJUSTED AND ADJUSTED MEAN BIOLOGY ACHIEVEMENT SCORES ON THE TOTAL AND SUB-TESTS OF UNIVERSITY STUDENTS ACROSS TREATMENT LEVELS AND LOCUS OF CONTROL

		Total Test		Sub-Tests					
				Recall		Comprehension		Above Comprehension	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Treatment	Diagnostic Prescriptive	57.5	8.6	30.7	5.2	13.6	2.9	12.9	3.7
		58.0*		31.0		13.7*		13.1*	
	Objectives Only	53.4	8.4	28.1	5.9	13.7	2.1	11.6	2.2
		52.9*		27.8*		13.6*		11.5	
Locus Of Control	Internal	58.5	6.7	28.6	6.7	13.5	2.5	16.0	16.6
		58.3*		28.7*		13.5*		16.0*	
	External	59.4	10.3	30.1	4.5	13.8	2.5	15.4	15.7
		59.6*		30.0*		13.7*		15.5*	

*Adjusted for selection bias on the average of three unit tests taken prior to treatment.

TABLE 3

RESULTS OF GLM PROCEDURES TESTING THE EFFECTS OF THE NUMBER OF DIAGNOSTIC-PRESCRIPTIVE TESTS TAKEN ON ACHIEVEMENT
N=172

SOURCE: # OF D-P TESTS TAKEN	DF	TYPE IV SS	E	P
FOR EXAM 1	1	4.383	5.69	0.0182
FOR EXAM 2	1	13.672	19.44	0.0001
FOR EXAM 3	1	10.480	12.06	0.0007
TOTAL	1	12.292	15.62	0.0001

NOTE: LOCUS OF CONTROL, ACHIEVEMENT MOTIVATION, AND ACADEMIC APTITUDE WERE CONTROLLED.

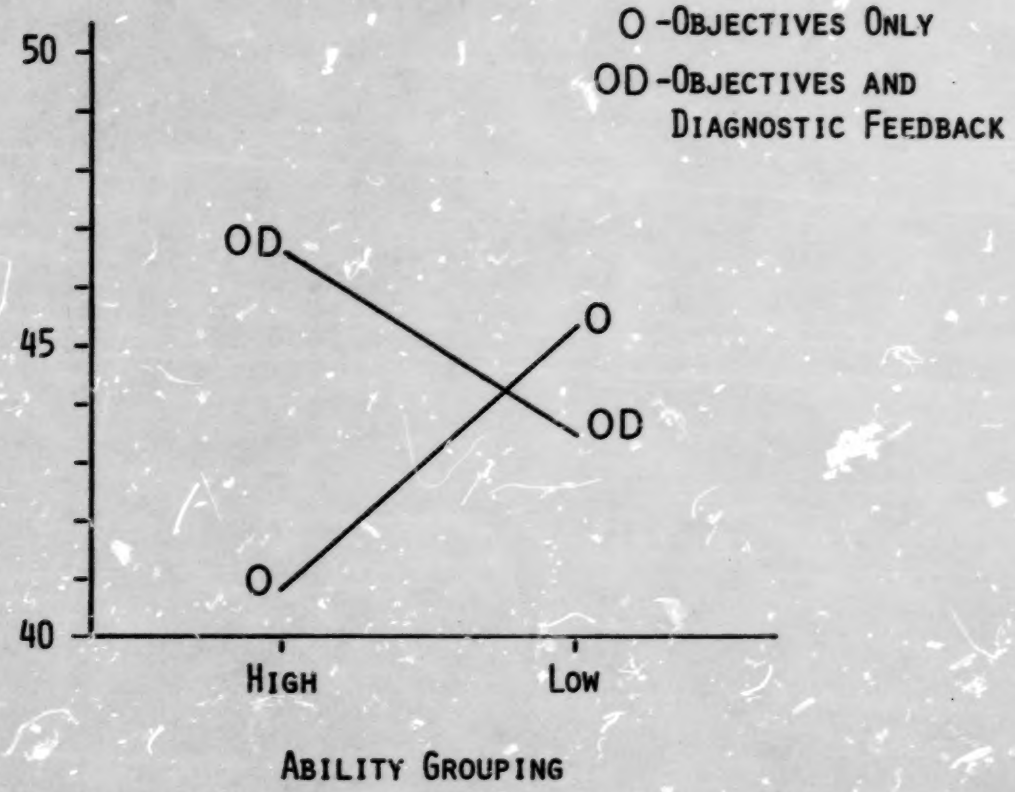

Figure 1. Treatment X Ability interaction on the Animal Behavior unit examination during the first quarter.